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MICROREACTOR FOR CATALYTIC OXIDATION OF VOC: CHARACTERISATION AND EFFICIENCY

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Abstract

Over recent years, microsystems have become of a great interest as heat exchangers, mixers or reactors. The main interests of these systems are to offer high heat and mass transfer properties, as well as high adaptabilities in terms of process design by numbering up of microstructured elements. Moreover, the transport properties of these devices enable new advanced technologies in catalytic processes. Amongst the various fields of their industrial potentiality, one of the applications of the catalytic microreactors is their possible integration into small-scale localized air treatment processes. In fact, much of industrial air pollution comes from enclosed sources. Thus, catalytic microsystems could be implemented for the removal of volatile organic compounds (VOC) in various industrial environments such as drying, painting, varnishing and dry-cleaning workshops.

Indeed, removal of air pollutants such as Volatile Organic Compounds (VOC) is a major health and environmental concern. VOC pollution is usually treated by means of adsorption and/or combustion processes. However, catalytic oxidation is an alternative destructive process for VOC abatement which has many advantages, such as high combustion efficiency, extremely low emission of NO_x and comparatively to the combustion, the reaction occurs at lower temperatures. While catalytic oxidation is generally carried out in a catalytic fixed bed reactor, microreactors offer the advantage of being adaptable and consequently allow the design of appropriate catalytic processes whatever the scale and the effluent.

We present here a catalytic microreactor that enables VOC oxidation. The microdevice is composed of silicon platelets etched by using DRIE technique (Deep Reactive Ion Etching). It is possible to etch channels of various depth and widths (500µm width x 200µm depth, 200µm width x 100µm depth and 100µm width x 50µm depth) in the platelets in a reproducible way. Each microstructured platelet is made up of parallel microchannels and the active catalyst phase (Pt) was deposited onto the walls of the microchannels by the thermal evaporation technique. Using air flow rates varying between 16 and 180 NL/h with concentrations ranging from 1000 to 10000 ppm, the performance of the microreactor was studied towards acetone and toluene oxidation. The deep oxidation of the VOCs in air was carried out at increasing temperatures giving ignition curves.

Moreover, simulations of the hydrodynamics have allowed the determination of non-measurable hydrodynamic characteristics of the microreactor such as the mean residence time and the gas flow distribution. In particular, CFD simulations of the flow through the microreactor were carried out with channel dimensions 500µm x 200µm. In addition to analyzing the flow patterns within the microreactor, the residence time distributions were characterized in regards to temperature and gas stream flow rate.